RESULTS

Growth and Lipid Profile

As presented in Table 2, the initial body weights were 202.50 ± 1.08, 204.17 ± 1.18 and 204.86 ± 1.54 g in NF, MF and HF groups, respectively. At the end of dietary period, there was a significant increases of body weight in each group compared with its initial value (297.66 ± 4.28, 295.17 ± 4.26 and 305.66 ± 5.74 g in NF, MF and HF groups, respectively, all $p<0.01$). The average weight gains were comparable among the dietary groups, about 47, 45 and 49% in NF, MF and HF groups, respectively. An analysis of dietary records showed that the cumulative food intake over 10 wk-exercise training in NF, MF and HF were 4452.85 ± 26.83, 4169.62 ± 23.83, and 2863.91 ± 15.63 g, respectively, which corresponded to total energy intake of 17677.85 ± 106.51, 17424.88 ± 99.55 and 17496.76 ± 93.85 Kcal in NF, MF and HF, respectively. No significant differences in total energy intake were noted between the dietary groups ($p<0.05$).

After 10 weeks of dietary intervention and training, the plasma triacylglycerol concentration in HF group (81.93 ± 2.91 mg/dl) was significantly higher as compared with the value noted in NF and MF groups (37.23 ± 2.75 and 38.61 ± 3.47 mg/dl, respectively) (both $p<0.01$) (Table 3). However, there were no appreciable differences in plasma lipoprotein cholerterol among NF, MF and HF groups ($p<0.05$). There were also no significant differences in plasma cholesterol concentrations between dietary groups (48.44 ± 2.91, 39.63 ± 2.81 and 48.73 ± 4.69 mg/dl in NF, MF and HF groups, respectively, $p<0.05$).

Endurance Time

As illustrated in Figure 1, the time to exhaustion was measured and presented as endurance time. Trained rats fed moderate or high fat diet ran significantly longer (107.10 ± 1.12 or 131.92 ± 2.87 min in MF or HF group, respectively) than those consumed normal fat diet (67.22 ± 0.74 min)(both $p<0.01$). Of the two groups received diet with increasing fat content, the HF group significantly ran longer than MF group ($p<0.01$).

Table 2 Effects of dietary fat on body weight.

Body weight (g)	Group		
	NF	**MF**	**HF**
Initial	202.50 ± 1.08	204.17 ± 1.18	204.86 ± 1.54
End of week 10	297.66 ± 4.28 *	295.17 ± 4.26 *	305.66 ± 5.74 *

Each value represents mean ± SE from 24 rats. NF; normal fat diet, MF; moderate fat diet, HF; high fat diet. * ; significantly different from initial, $p < 0.01$

Table 3 Effects of dietary fat on lipid profiles.

Lipid Profiles	Group		
	NF	MF	HF
Triacylglycerol (mg/dl)	37.23 ± 2.75	38.61 ± 3.47	81.93 ± 2.91 [a,b]
Total Cholesterol (mg/dl)	48.44 ± 2.91	39.63 ± 2.81	48.73 ± 4.69
HDL-C (mg/dl)	31.00 ± 1.82	34.50 ± 0.50	39.17 ± 4.94
LDL-C (mg/dl)	6.20 ± 0.74	5.50 ± 0.50	5.67 ± 0.49
VLDL-C (mg/dl)	25.80 ± 2.82	13.00 ± 5.00	13.00 ± 2.75

HDL-C; high density lipoprotein, LDL-C; low density lipoprotein, VLDL-C; very low density lipoprotein. Each value represents mean ± SE from 8 rats. NF; normal fat diet, MF; moderate fat diet, HF; high fat diet. [a] ; significantly different from NF group, $p < 0.01$. [b]; significantly different from MF group, $p < 0.01$.

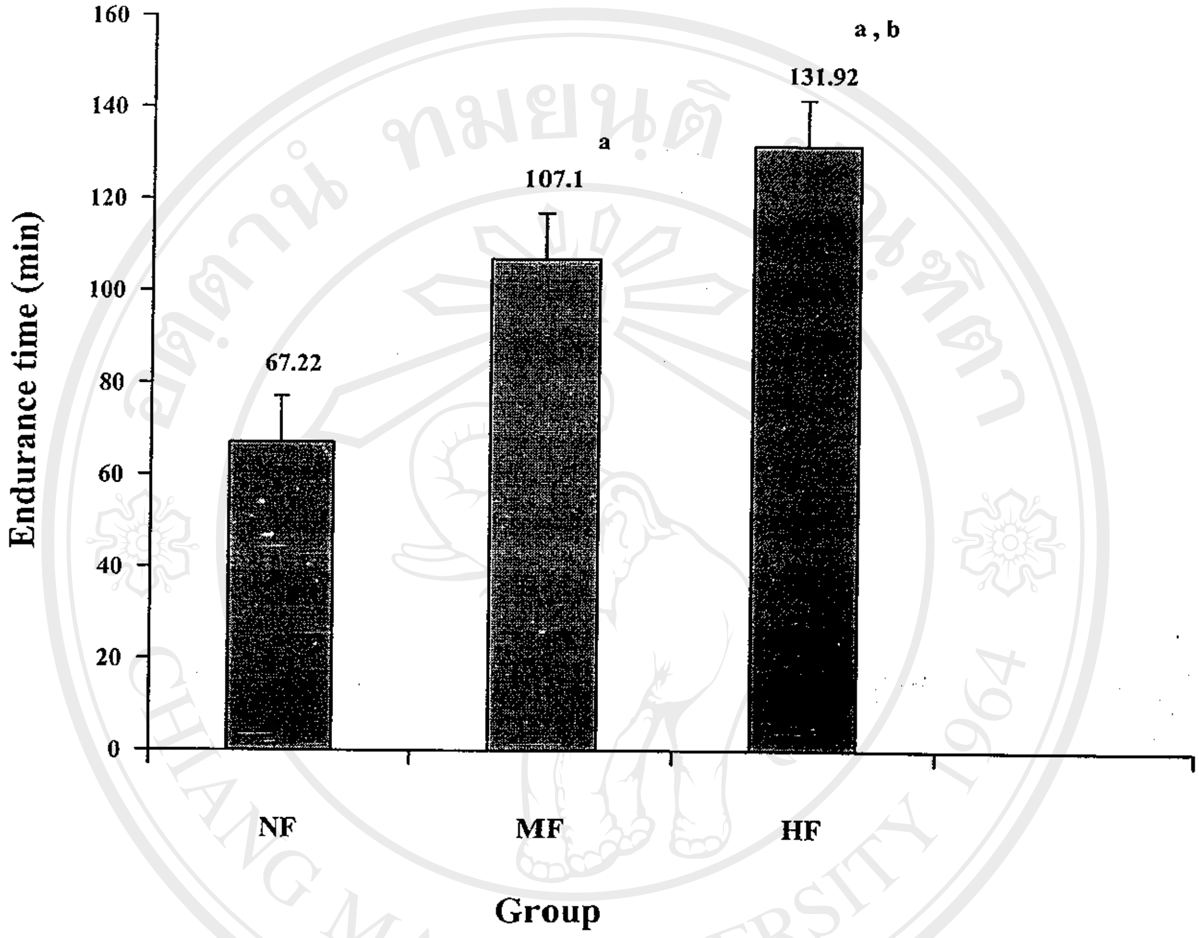


Figure 1 Effects of dietary fat on endurance time among the normal fat diet (NF), moderate fat diet (MF) and high fat diet (HF) groups.

Each value represents mean ± SE from 8 rats. [a]; significantly different from NF group, $p < 0.01$. [b]; significantly different from MF group, $p < 0.01$.

Tissue Substrate Concentrations

Table 4 summarizes the effects of dietary fat on tissue glycogen and triacylglycerol storages. The glycogen concentration in vastus lateralis muscle was significantly lower in MF and HF groups (1.87 ± 0.06 and 1.33 ± 0.09 mg /gm tissue, respectively) compared with NF group (2.22 ± 0.03 mg /gm tissue)(both $p<0.01$). As for the soleus muscle, the decreases of resting glycogen concentrations (2.04 ± 0.07 or 1.46 ± 0.03 mg /gm tissue, respectively) in the MF and HF groups were significant differed from NF group (3.00 ± 0.08 mg /gm tissue)(both $p<0.01$). As compared with the MF group, however, the resting glycogen concentrations in both vastus lateralis and soleus muscles in HF group were significantly lower ($p<0.01$). The liver glycogen storage was highest in NF group (26.20 ± 0.53 mg /gm tissue), being significantly different from the values obtained in MF and HF groups (23.31 ± 0.58 and 17.15 ± 0.40 mg /gm tissue, respectively)(both $p<0.01$). There was also a significant difference in the resting concentration of liver glycogen between MF and HF groups ($p<0.01$).

In contrast to the tissue glycogen, the storage of triacylglycerol in muscle and liver was enhanced as the dietary fat content was increased. The resting triacylglycerol concentration in vastus lateralis or soleus muscle was highest in HF group (9.49 ± 0.21 or 11.15 ± 0.32 mg /gm tissue) whereas it was lowest in NF group (1.82 ± 0.04 or 5.34 ± 0.09 mg /gm tissue). Significant differences in resting triacylglycerol concentrations in both muscles were found between NF and HF group ($p<0.01$). The values of resting intramuscular triacylglycerol concentrations, both vastus lateralis and soleus muscles in MF group (3.34 ± 0.03 and 6.87 ± 0.22 mg /gm tissue), were lower than in HF group ($p<0.01$) but higher than in NF group ($p<0.01$). The resting triacylglycerol concentration in liver in HF (23.52 ± 0.40 mg /gm tissue) significantly differed from the value presented in MF and NF groups (12.35 ± 0.46 and 10.58 ± 0.25 mg /gm tissue, respectively, $p<0.01$). There was also a significant difference in the liver triacylglycerol storage between NF and MF groups ($p<0.01$). Comparison of glycogen and triacylglycerol concentrations stored in muscles and liver among the dietary groups is illustrated in Figure 2.

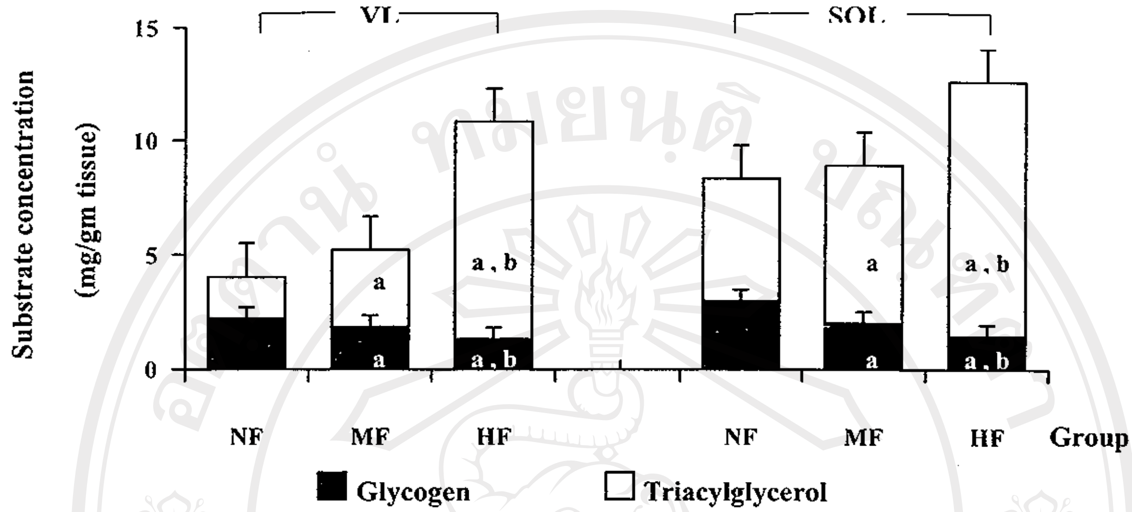
As shown in Table 5, the glycogen concentrations in vastus lateralis and soleus muscles after exercise test were significantly decreased in NF and MF groups compared with its value obtained before exercise (both $p<0.01$). When expressed as the average utilization rate, trained rats in NF group had higher rate of glycogen utilization in vastus lateralis or soleus muscles (25.92

Table 4 Effects of dietary fat on the tissue glycogen and triacylglycerol storage.

Substrate	Group		
	NF	MF	HF
Glycogen (mg/gm tissue)			
Vastus lateralis muscle	2.22 ± 0.03	1.87 ± 0.06 [a]	1.33 ± 0.09 [a,b]
Soleus muscle	3.00 ± 0.08	2.04 ± 0.07 [a]	1.46 ± 0.03 [a,b]
Liver	26.20 ± 0.53	23.31 ± 0.58 [a]	17.15 ± 0.40 [a,b]
Triacylglycerol (mg/gm tissue)			
Vastus lateralis muscle	1.82 ± 0.04	3.34 ± 0.03 [a]	9.49 ± 0.21 [a,b]
Soleus muscle	5.34 ± 0.09	6.87 ± 0.22 [a]	11.15 ± 0.32 [a,b]
Liver	10.58 ± 0.25	12.35 ± 0.46 [a]	23.52 ± 0.40 [a,b]

Each value represents mean ± SE from 8 rats. NF; normal fat diet, MF; moderate fat diet, HF; high fat diet. [a] ; significantly different from NF group, $p < 0.01$. [b] ; significantly different from MF group, $p < 0.01$.

A. Muscle



B. Liver

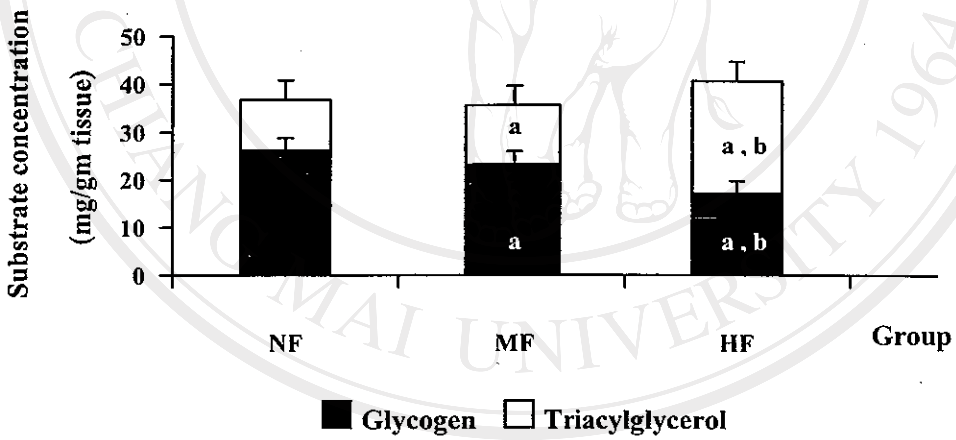


Figure 2 Comparison of glycogen and triacylglycerol concentrations in muscle (A) and liver (B) among the normal fat diet (NF), moderate fat diet (MF) and high fat diet (HF) groups. VL : vastus lateralis muscle, SOL : soleus muscle. Each value represents mean ± SE from 8 rats. [a] ; significantly different from NF group, $p < 0.01$. [b] ; significantly different from MF group, $p < 0.01$.

Table 5 Effects of dietary fat on tissue glycogen concentration after exercise test.

Tissue	Group		
	NF	MF	HF
Vastus lateralis muscle			
at rest (mg/gm tissue)	2.22 ± 0.03	1.87 ± 0.06 [a]	1.33 ± 0.09 [a,b]
after exercise test (mg/gm tissue)	1.70 ± 0.01 *	1.68 ± 0.02 *	1.33 ± 0.02
utilization rate (μg/gm tissue/min)	25.92 ± 0.59	5.33 ± 0.60 [a]	0.01 ± 0.42 [a,b]
Soleus muscle			
at rest (mg/gm tissue)	3.00 ± 0.08	2.04 ± 0.07 [a]	1.46 ± 0.03 [a,b]
after exercise test (mg/gm tissue)	2.53 ± 0.04 *	1.80 ± 0.02 *	1.46 ± 0.02
utilization rate (μg/gm tissue/min)	23.51 ± 1.86	6.72 ± 0.48 [a]	1.25 ± 0.44 [a,b]
Liver			
at rest (mg/gm tissue)	26.20 ± 0.53	23.31 ± 0.58 [a]	17.15 ± 0.40 [a,b]
after exercise test (mg/gm tissue)	19.99 ± 0.43 *	19.52 ± 0.38 *	16.55 ± 0.27
mobilization rate (μg/gm tissue/min)	310.38 ± 21.44	108.32 ± 10.98 [a]	27.42 ± 4.33 [a,b]
Total utilization (μm/gm tissue/min)	336.77 ± 21.65	113.88 ± 10.96 [a]	27.79 ± 4.33 [a,b]

Each value represents mean ± SE from 8 rats. NF; normal fat diet, MF; moderate fat diet, HF; high fat diet. The glycogen utilization rate in muscle is expressed as average rate of use over time and does not necessarily reflect a linear relationship. Likewise, the liver glycogen mobilization rate represents average rate of mobilization over time. * ; significantly different from rest, $p < 0.05$. [a] ; significantly different from NF group, $p < 0.01$. [b]; significantly different from MF group, $p < 0.01$.

± 0.59 or 23.51 ± 1.86 μg/gm tissue/min, respectively) than in MF group (5.33 ± 0.60 or 6.72 ± 0.48 μg/gm tissue/min)($p<0.01$). In HF group, there was almost no changes of intramuscular glycogen concentration after exercise. Correspondingly, the average utilization of glycogen was depressed in vastus lateralis muscle (0.01 ± 0.42 μg/gm tissue/min) and considerably low soleus muscle (1.25 ± 0.44 μg/gm tissue/min). There was a slight decrease of liver glycogen concentration after exercise test, about 4%, in HF group but the substantial decreases were noted in NF and MF groups, about 24 and 16%, respectively. The average rate of liver glycogen mobilization was highest in NF group (310.38 ± 21.44 μg/gm tissue/min), being significantly different from the NF and MF group (108.32 ± 10.98 and 27.42 ± 4.33 μg/gm tissue/min, both $p<0.01$). A significant difference was also presented between HF and MF groups ($p<0.01$).

The change of tissue triacylglycerol concentrations after exercise test is summarized in Table 6. An apparent decrease of intramuscular triacylglycerol concentration, either vastus lateralis or soleus muscle, in response to exercise was observed in MF and HF groups (both $p<0.05$). The highest average rate of triacylglycerol utilization in both muscles was noted in HF group (66.65 ± 2.37 and 106.68 ± 13.38 μg/gm tissue/min in vastus lateralis and soleus muscles, respectively). As compared with HF group, the rate of triacylglycerol utilization values in both vastus lateralis and soleus muscles in MF (15.35 ± 1.45 and 27.92 ± 4.94 μg/gm tissue/min, both $p<0.01$) or NF group (4.86 ± 0.95 and 17.15 ± 3.47 μg/gm tissue/min, both $p<0.01$) were significantly low. There were also significant differences in the average rates of muscle triacylglycerol utilization between NF and HF groups ($p<0.01$). As for the liver, the triacylglycerol concentration after exercise test significantly decreased by 16 % and 22% in MF and HF groups, respectively but a slight decrease was noted in NF group (7%). The average rates of liver triacylglycerol mobilization in MF and NF groups were comparable (56.61 ± 5.78 and 44.34 ± 9.86 μg/gm tissue/min) but significantly lower than HF group (113.34 ± 6.50 μg/gm tissue/min, both $p<0.01$). Comparison of tissue glycogen and triacylglycerol utilization rate during exercise test is depicted in Figure 3. Dietary fat did affect the substrate utilization during exercise test. The triacylglycerol utilization was increased as the dietary fat content increased. The total triacylglycerol (muscles and liver) utilization rate was in order of HF>MF>NF (286.66 ± 8.31, 99.88 ± 6.26 and 58.49 ± 10.99μg/gm tissue/min, respectively). The total glycogen (muscles

Table 6 Effects of dietary fat on tissue triacylglycerol concentration after exercise test.

Tissue	Group		
	NF	MF	HF
Vastus lateralis muscle			
at rest (mg/gm tissue)	1.82 ± 0.04	3.34 ± 0.03 [a]	9.49 ± 0.21 [a, b]
after exercise test (mg/gm tissue)	1.72 ± 0.02 *	2.80 ± 0.05 *	6.49 ± 0.11 *
utilization rate (μg/gm tissue/min)	4.86 ± 0.95	15.35 ± 1.45 [a]	66.65 ± 2.37 [a, b]
Soleus muscle			
at rest (mg/gm tissue)	5.34 ± 0.09	6.87 ± 0.22 [a]	11.15 ± 0.32 [a, b]
after exercise test (mg/gm tissue)	5.08 ± 0.08	5.89 ± 0.17 *	6.35 ± 0.16 *
utilization rate (μg/gm tissue/min)	17.15 ± 3.47	27.92 ± 4.94	106.68 ± 13.38 [a, b]
Liver			
at rest (mg/gm tissue)	10.58 ± 0.25	12.35 ± 0.46 [a]	23.52 ± 0.40 [a, b]
after exercise test (mg/gm tissue)	9.81 ± 0.21 *	10.37 ± 0.20 *	18.42 ± 0.29 *
mobilization rate (μg/gm tissue/min)	44.34 ± 9.86	56.61 ± 5.78	113.34 ± 6.50 [a, b]
Total utilization (μg/gm tissue/min)	58.49 ± 10.99	99.88 ± 6.26 [a]	286.66 ± 8.31 [a, b]

Each value represents mean ± SE from 8 rats. NF; normal fat diet, MF; moderate fat diet, HF; high fat diet. The triacylglycerol utilization rate in muscle is expressed as average rate of use over time and does not necessarily reflect a linear relationship. Likewise, the liver triacylglycerol mobilization rate represents average rate of mobilization over time. * ; significantly different from rest, $p < 0.05$. [a] ; significantly different from NF group, $p < 0.01$. [b] ; significantly different from MF group, $p < 0.01$.

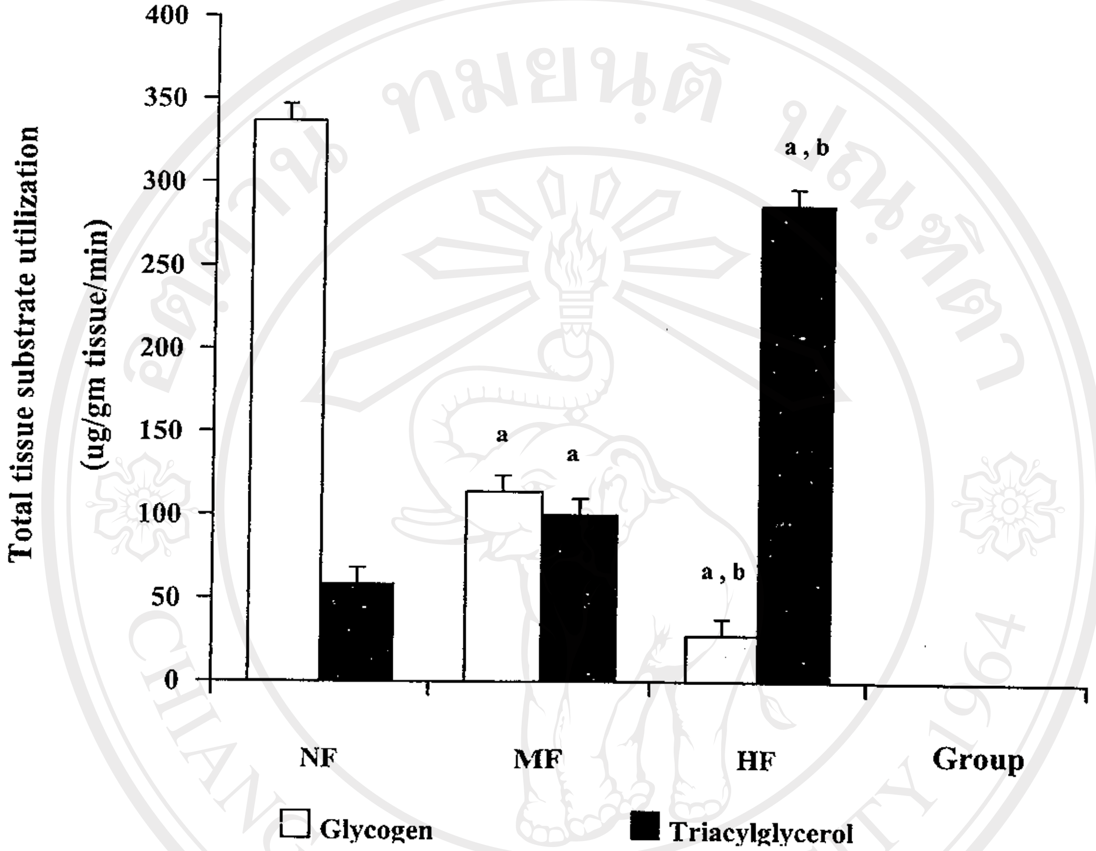


Figure 3. Comparison of dietary fat on total tissue utilization after exercise test among the normal fat diet (NF), moderate fat diet (MF) and high fat diet (HF) groups.

Each value represents mean ± SE from 8 rats. [a]; significantly different from NF group, $p < 0.01$. [b]; significantly different from MF group, $p < 0.01$.

and liver) utilization rate was significantly depressed in HF group (27.79 ± 4.33 μg/gm tissue/min) whereas it was considerably increased in NF group (336.77 ± 21.65 μg/gm tissue/min) compared with MF group (113.88 ± 10.96 μg/gm tissue/min)(all $p<0.01$).

The effects of dietary fat on tissue glycogen concentration after endurance exercise are shown in Table 7. The glycogen concentrations in muscles as well as liver after exhaustion were depleted in all groups (all $p<0.05$). The average rate of glycogen utilization in vastus lateralis muscle was highest in NF group (13.56 ± 0.25 μg/gm tissue/min) and it was lowering as the dietary fat content was increasing (4.37 ± 0.13 and 1.27 ± 0.09 μg/gm tissue/min in MF and HF groups, respectively). Similarly, the NF group had significantly higher average utilization rate of glycogen in soleus muscle (22.07 ± 0.43 μg/gm tissue/min) compared with MF and HF groups (9.59 ± 0.21 and 1.34 ± 0.18 μg/gm tissue/min, both $p<0.01$). Of the two groups received increasing fat intake, the average rates of glycogen utilization in both vastus lateralis and soleus muscles were significantly greater in MF than in HF groups ($p<0.01$). The average mobilization rate of liver glycogen in HF group was substantially lower (27.81 ± 2.29 μg/gm tissue/min) compared with MF and NF groups (64.37 ± 4.13 and 99.77 ± 6.00 μg/gm tissue/min, both $p<0.01$). A significant difference in the average mobilization rate of liver glycogen was also noted between MF and NF groups ($p<0.01$).

As shown in Table 8, the substantial decreases of tissue triacylglycerol concentrations after exhausting exercise were presented in all groups (all $p<0.05$). High fat diet enhanced the intramuscular triacylglycerol utilization (52.96 ± 0.36 and 58.65 ± 0.80 μg/gm tissue/min in vastus lateralis and soleus muscles). Compared with HF group, the rates of triacylglycerol utilization in both vastus lateralis and soleus muscles in NF (5.87 ± 0.36 and 43.62 ± 1.06 μg/gm tissue/min) or MF (13.04 ± 0.33 and 38.89 ± 0.55 μg/gm tissue/min) groups were significantly low (both $p<0.01$). There were significant differences in the triacylglycerol utilization rates in both muscles between NF and MF groups (both $p<0.01$). In liver, the rate of triacylglycerol mobilization was in order of HF > MF > NF groups (50.72 ± 2.36, 28.41 ± 3.34 and 12.62 ± 2.72 μg/gm tissue/min, respectively). Significant differences in the rate of liver triacylglycerol mobilization were found between HF and MF ($p<0.01$), HF and NF ($p<0.01$), and MF and NF groups ($p<0.01$). Figure 4 demonstrates the comparison of dietary fat on total tissue glycogen and triacylglycerol utilization rates during endurance exercise among the dietary groups.

Table 7 Effects of dietary fat on tissue glycogen utilization after endurance exercise.

Tissue	**Group**		
	NF	**MF**	**HF**
Vastus lateralis muscle			
at rest (mg/gm tissue)	2.22 ± 0.03	1.87 ± 0.06 [a]	1.33 ± 0.09 [a,b]
after exhastion (mg/gm tissue)	1.31 ± 0.02 *	1.40 ± 0.01 *	1.16 ± 0.01 *
utilization rate (µg/gm tissue/min)	13.56 ± 0.25	4.37 ± 0.13 [a]	1.27 ± 0.09 [a,b]
Soleus muscle			
at rest (mg/gm tissue)	3.00 ± 0.08	2.04 ± 0.07 [a]	1.46 ± 0.03 [a,b]
after exhastion (mg/gm tissue)	1.52 ± 0.03 *	1.01 ± 0.02 *	1.28 ± 0.02 *
utilization rate (µg/gm tissue/min)	22.07 ± 0.43	9.59 ± 0.21 [a]	1.34 ± 0.18 [a,b]
Liver			
at rest (mg/gm tissue)	26.20 ± 0.53	23.31 ± 0.58 [a]	17.15 ± 0.40 [a,b]
after exhastion (mg/gm tissue)	19.49 ± 0.40 *	16.42 ± 0.44 *	13.48 ± 0.30 *
mobilization rate (µg/gm tissue/min)	99.77 ± 6.00	64.37 ± 4.13 [a]	27.81 ± 2.29 [a,b]
Total utilization (µg/gm tissue/min)	135.41 ± 6.45	78.32 ± 4.24 [a]	30.42 ± 2.26 [a,b]

Each value represents mean ± SE from 8 rats. NF; normal fat diet, MF; moderate fat diet, HF; high fat diet. The glycogen utilization rate in muscle is expressed as average rate of use over time and does not necessarily reflect a linear relationship. Likewise, the liver glycogen mobilization rate represents average rate of mobilization over time. *; significantly different from rest, $p < 0.05$. [a]; significantly different from NF group, $p < 0.01$. [b]; significantly different from MF group, $p < 0.01$.

Table 8 Effects of dietary fat on tissue triacylglycerol utilization after endurance exercise.

Tissue	Group		
	NF	MF	HF
Vastus lateralis muscle			
at rest (mg/gm tissue)	1.82 ± 0.04	3.34 ± 0.03 [a]	9.49 ± 0.21 [a,b]
after exhaustion (mg/gm tissue)	1.43 ± 0.02 *	1.94 ± 0.04 *	2.50 ± 0.05 *
utilization rate (μg/gm tissue/min)	5.87 ± 0.36	13.04 ± 0.33 [a]	52.96± 0.36 [a,b]
Soleus muscle			
at rest (mg/gm tissue)	5.34 ± 0.09	6.87 ± 0.22 [a]	11.15 ± 0.32 [a,b]
after exhastion (mg/gm tissue)	2.41 ± 0.07 *	2.70 ± 0.06 *	3.41 ± 0.11 *
utilization rate (μg/gm tissue/min)	43.62 ± 1.06	38.89 ± 0.55 [a]	58.65 ± 0.80 [a,b]
Liver			
at rest (mg/gm tissue)	10.58 ± 0.25	12.35 ± 0.46 [a]	23.52 ± 0.40 [a,b]
after exhastion (mg/gm tissue)	9.73 ± 0.18 *	9.31 ± 0.36 *	16.83 ± 0.31 *
mobilization rate (μg/gm tissue/min)	12.62 ± 2.72	28.41 ± 3.34 [a]	50.72 ± 2.36 [a,b]
Total utilization (μg/gm tissue/min)	62.12 ± 2.74	80.35 ± 3.33 [a]	162.33 ± 2.16 [a,b]

Each value represents mean ± SE from 8 rats. NF; normal fat diet, MF; moderate fat diet, HF; high fat diet. The triacylglycerol utilization rate in muscle is expressed as average rate of use over time and does not necessarily reflect a linear relationship. Likewise, the liver triacylglycerol mobilization rate represents average rate of mobilization over time. *; significantly different from rest, $p < 0.05$. [a] ; significantly different from NF group, $p < 0.01$. [b]; significantly different from MF group, $p < 0.01$.

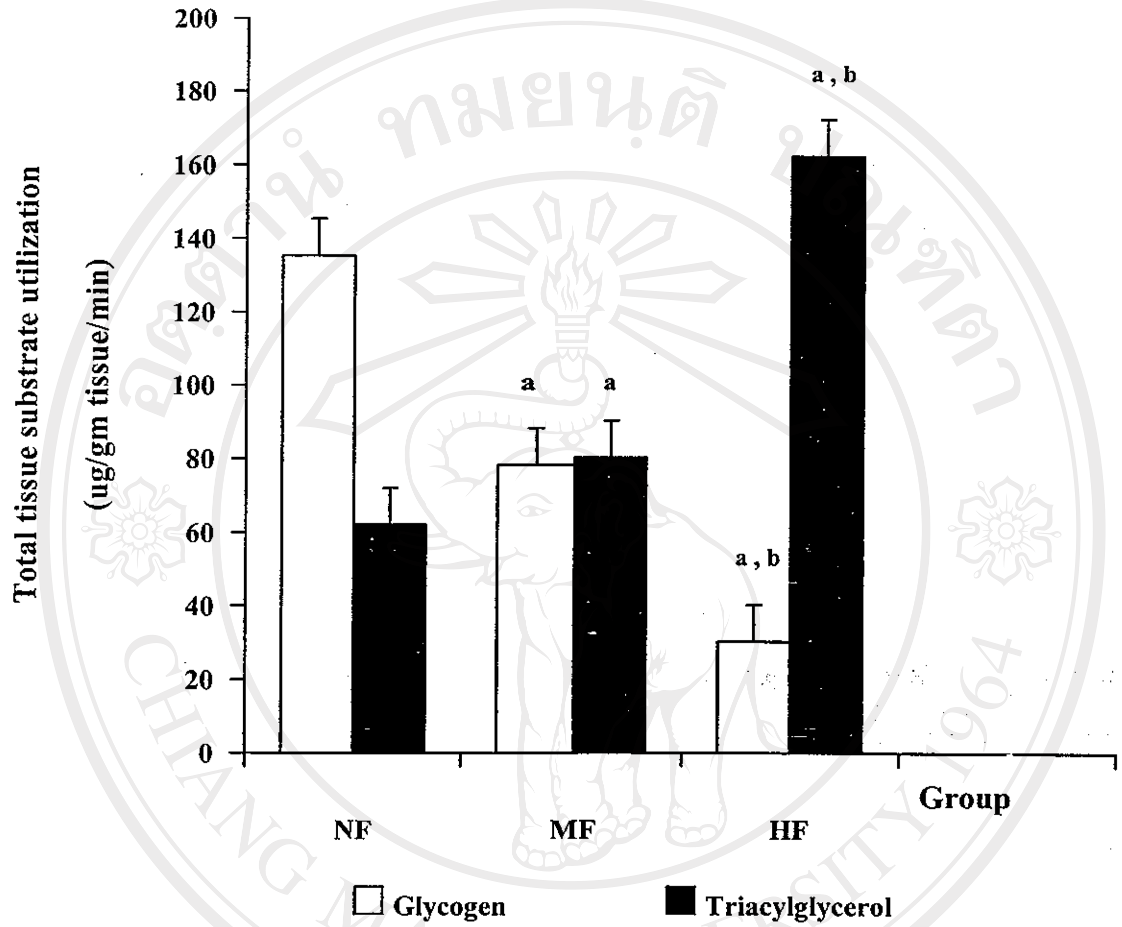


Figure 4 Comparison of dietary fat on total tissue utilization after endurance exercise among the normal fat diet (NF), moderate fat diet (MF) and high fat diet (HF) groups.

Each value represents mean ± SE from 8 rats. [a] ; significantly different from NF group, $p < 0.01$. [b] ; significantly different from MF group, $p < 0.01$.

Enzymatic activity

Table 9 shows the CS and 3-HAD activity in vastus lateralis and soleus muscles. The effect of dietary fat on enzyme activity was prominent for CS. Both MF and HF groups had significantly higher CS activity in the vastus lateralis muscle (13.58 ± 0.56 and 17.14 ± 0.70 mM/gm tissue/min) compared with the NF group (9.44 ± 0.28 mM/gm tissue/min, p<0.01). Similarly, a significant increase in CS activity in soleus muscle was presented in trained rats fed diet with increasing fat contents (23.11 ± 0.73 and 27.33 ± 0.79 mM/gm tissue/min in MF and HF, respectively) in respect to the NF group (15.67 ± 0.72 mM/gm tissue/min)(both p<0.01). Of the two groups consuming fat diet, the CS activity values both in vastus lateralis and soleus muscles were significantly higher in HF group than MF group (p<0.01).

Dietary fat also produced an elevation in 3-HAD activity. In vastus lateralis muscle, however, this effect was consistent with high fat diet. The 3-HAD activity in vastus lateralis muscle in NF and MF groups were comparable (0.85 ± 0.02 and 0.99 ± 0.08 mM/gm tissue/min, respectively), but significantly lower compared with the value noted in HF group (1.74 ± 0.11 mM/gm tissue/min)(both p<0.01). In soleus muscle, both MF and HF groups had significantly higher activity (1.96 ± 0.03 and 2.37 ± 0.08 mM/gm tissue/min, respectively) than NF group (1.71 ± 0.05 mM/gm tissue/min)(both p<0.01). There was also a significant difference in the 3-HAD activity in soleus muscle between MF and HF groups (p<0.01).

Blood born substrates

Glucose : As shown in Table 10, the resting plasma glucose concentrations were similar in all dietary groups (169.79 ± 5.28, 164.60 ± 2.08 and 170.85 ± 4.92 mg/dl in NF, MF and HF groups, respectively). After exercise test, there were significant elevations of plasma glucose concentrations in all groups except for HF group compared with their comparable rested values (195.84 ± 3.03, 188.47 ± 2.05 and 180.12 ± 4.74 mg/dl in NF, MF and HF groups, respectively)(p<0.05). At exhaustion, the plasma glucose level in each dietary group however fell and approached to its resting value (169.18 ± 4.51, 167.84 ± 5.09 and 172.21 ± 3.15 mg/dl in NF, MF and HF groups, respectively).

Glycerol : The plasma glycerol concentrations in MF and HF groups (12.42 ± 0.48 and 16.44 ± 0.73 mg/dl) were significantly higher than in NF group (8.28 ± 0.77 mg/dl)(both p<0.01).

Table 9 Effects of dietary fat on enzymatic activity.

Tissue	Group		
	NF	MF	HF
Vastus lateralis muscle			
CS (mM/gm tissue/min)	9.44 ± 0.28	13.58 ± 0.56 [a]	17.14 ± 0.70 [a,b]
3-HAD (mM/gm tissue/min)	0.85 ± 0.02	0.99 ± 0.08	1.74 ± 0.11 [a,b]
Soleus muscle			
CS (mM/gm tissue/min)	15.67 ± 0.72	23.11 ± 0.73 [a]	27.33 ± 0.79 [a,b]
3-HAD (mM/gm tissue/min)	1.71 ± 0.05	1.96 ± 0.03 [a]	2.37 ± 0.08 [a,b]

Each value represents mean ± SE from 8 rats. NF; normal fat diet, MF; moderate fat diet, HF; high fat diet. CS; Citrate synthase activity, 3-HAD; 3-hydroxyacyl CoA dehydrogenase activity. [a]; significantly different from NF group, $p < 0.01$. [b]; significantly different from MF group, $p < 0.01$.

There was no change of plasma glycerol concentration in NF group after exercise test or endurance exercise (10.36 ± 0.55 or 9.92 ± 0.87 mg/dl). There was a significant increase of plasma glycerol level in MF group after exhaustion (18.81 ± 1.32 mg/dl, $p<0.05$) though no change was found after exercise (13.81 ± 0.29 mg/dl). In contrast, the plasma glycerol levels in HF group both after exercise test and at exhaustion were significant decreased (10.78 ± 0.47 and 10.14 ± 0.57 mg/dl)(both $p<0.05$) compared with its resting value.

Triacylglycerol : The resting plasma triacylglycerol levels were similar in NF and MF groups (37.23 ± 2.75 and 38.61 ± 3.47 mg/dl) whereas the HF group showed a significant increase (81.93 ± 2.91 mg/dl) compared with the values noted in MF and NF groups (both $p<0.01$). The plasma triacylglycerol concentrations after exercise test or endurance exercise in NF group (47.55 ± 6.82 or 40.34 ± 2.80 mg/dl) were similar to its rested value. Although the plasma triacylglycerol level in MF group was not changed after exercise (40.45 ± 4.61 mg/dl), it tended to be decreased after exhaustion (29.71 ± 3.72 mg/dl). In HF group, the plasma triacylglycerol concentrations either after exercise test or at exhaustion (33.13 ± 4.57 or 16.93 ± 1.54 mg/dl) were significantly decreased compared with its value in resting state (both $p<0.05$).

Lactate : The resting blood lactate concentration tended to be lower in HF group (2.96 ± 0.22 mmol/l) than in NF or MF group (3.86 ± 0.74 and 3.65 ± 0.42, respectively). All dietary groups had consistently increased lactate concentrations after exercise test (5.71 ± 0.14, 6.76 ± 0.57 and 4.19 ± 0.53 mmol/l, in NF, MF and HF groups, respectively)(all $p<0.01$) compared with their comparable rested values. The increased plasma lactate level appeared to be low in HF group although significant difference was found only between HF and NF groups ($p<0.05$). At exhaustion, only NF and MF groups showed significant increases of the plasma lactate concentrations (6.62 ± 0.31 and 5.2 ± 0.57 mmol/l, both $p<0.05$) in respect to its value observed in rested state. The plasma lactate level at exhaustion was significantly lower in MF group compared with NF group ($p<0.05$). In HF group, the plasma lactate concentration at exhaustion was lowest (3.39 ± 0.14 mmol/l), being significant differed from the values observed in MF and NF groups (both $p<0.05$).

Table 10 Effects of dietary fat on blood born substrates.

Substrate	Group		
	NF	MF	HF
Glucose (mg/dl)			
at rest	169.79 ± 5.28	164.60 ± 2.08	170.85 ± 4.92
after exercise test	195.84 ± 3.03 *	188.47 ± 2.50 *	180.12 ± 4.74 [aa]
after exhaustion	169.18 ± 4.51	167.84 ± 5.09	172.21 ± 3.15
Glycerol (mg/dl)			
at rest	8.28 ± 0.77	12.42 ± 0.48 [a]	16.44 ± 0.73 [a, b]
after exercise test	10.36 ± 0.55	13.81 ± 0.29 [aa]	10.78 ± 0.47 * [bb]
after exhaustion	9.92 ± 0.87	18.81 ± 1.32 * [aa]	10.14 ± 0.57 *
Triacylglycerol (mg/dl)			
at rest	37.23 ± 2.75	38.61 ± 3.47	81.93 ± 2.91 [a, b]
after exercise test	47.55 ± 6.82	40.45 ± 4.61 [aa]	33.13 ± 4.57 * [aa, bb]
after exhaustion	40.34 ± 2.80	29.71 ± 3.72	16.93 ± 1.54 *
Lactate (mmol/l)			
at rest	3.86 ± 0.74	3.65 ± 0.42	2.96 ± 0.22
after exercise test	5.71 ± 0.14 *	6.76 ± 0.57 *	4.19 ± 0.53 * [aa]
after exhaustion	6.62 ± 0.31 *	5.2 ± 0.57 * [aa]	3.39 ± 0.14 [aa bb]

Each value represents mean ± SE from 8 rats. NF; normal fat diet, MF; moderate fat diet, HF; high fat diet. * ; significantly different from rest group, $p < 0.05$. [a] ; significantly different from NF group, $p < 0.01$. [aa] ; significantly different from NF group, $p < 0.05$. [b] ; significantly different from MF group, $p < 0.01$. [bb] ; significantly different from MF group, $p < 0.05$.